

**WILL WE TRANSFORM
OURSELVES INTO A
NEW SPECIES BY
MANIPULATING DNA?**

By Mark Schoofs

MAN-MADE Man

Almost three decades ago, W. French Anderson started warning his colleagues about the ramifications of gene therapy, the medical alteration of people's DNA. Anderson was a pioneer in this new field, but he had become worried about it being misused. What if doctors altered the "germ line," the egg and sperm cells that transfer genes to future generations? And what if they didn't just try to cure disease but also to enhance people, to make them stronger or smarter? Then, Anderson feared, "we could end up with a eugenic society where genetic haves dominate the have-nots."

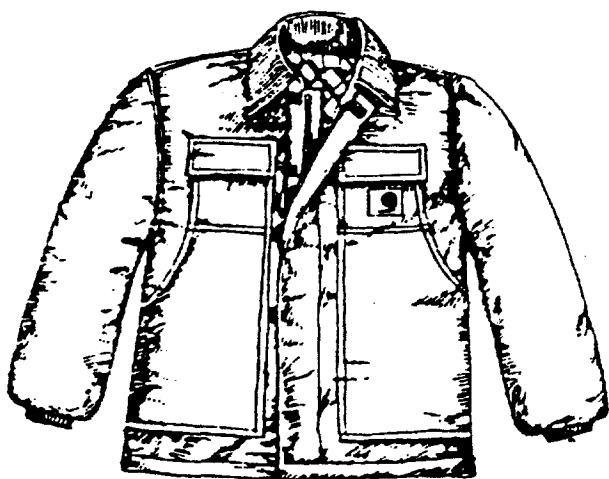
Back then, his colleagues thought his warnings were as bizarre as "concerns about property rights on Mars." No longer. Lee Silver, a Princeton microbiologist, has just published *Remaking Eden*, a book arguing that Anderson's fears are not only plausible but "inevitable."

Both genetics and reproductive technology have advanced with stunning speed, and now the two fields are converging into what Silver calls "reprogenetics." Parents will want the best for their children, and the marketplace will cater to that demand, starting with irresistible and seemingly benign services such as "genetic vaccines." (continued on page 36)



DAVE'S

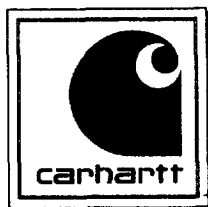
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But the menu will grow. Already, scientists routinely add or "knock out" genes from animal embryos, giving them all sorts of new traits. As such techniques are refined, regulation will be powerless to stop them from being used on humans, because, as Silver notes, "a reprogenetics clinic could easily be run on the scale of a small business anywhere in the world." Such consumer eugenics, he predicts, will not only lead to different biological castes, it might eventually split human beings into separate species.

EVEN SILVER THINKS speciation won't begin to happen for 350 years—and it is important to keep the pace of change in mind. The dilemmas of the far future will almost certainly center on reconfiguring DNA, but the problems of the near future will arise from merely knowing our genetic code. For the moment, we are mostly able to see things we cannot change. Thousands of disease genes have been discovered, but few cures have been found.

In addition, researchers have identified genes that correlate with all kinds of normal traits—including IQ. And in a powerful marriage of silicon and DNA, a "gene chip" has been invented that can diagnose hundreds of genetic conditions quickly and cheaply. Increasingly, we are able to see people in a new and atomized way—as the sum of their genes, each of which could be a basis for stigma. How we use this vision—as grounds for discrimination or a tool for enhancing health—will set the stage for how future generations use their power to change our genetic code.

IN THE MOVIE GATTACA, Ethan Hawke's character goes to a job interview, but instead of talking to him, the company just analyzes his DNA. Sci-fi? In fact, that sort of thing has been going on for years.

In the 1970s, an applicant to several medical schools had a parent who suffered from Huntington's chorea, a deadly inherited illness of the brain. Knowledge of his parent's illness was effectively a genetic test: The young man had a 50 per cent chance of developing the disease, though perhaps not until his eighties. Despite his high grades, the medical schools rejected him, reasoning that an expensive education would be wasted on someone who could die young.

"Horrendous," fumes Columbia University psychologist Nancy Wexler, who directed a government commission that uncovered this case. Wexler's mother also died from Huntington's, meaning that she, too, has a 50-50 chance of developing the disease. But Wexler's education was hardly a waste. She helped find the Huntington's gene.

WEXLER BELIEVES HER work will eventually lead to a cure, and that prospect is why genetic research will—and should—continue. But while the cures are still far away, genetic discrimination is here and now.

The Lawrence Berkeley Laboratories in California secretly tested the blood of its African American employees for sickle-cell anemia, according to an employee lawsuit. Just two years ago, a court struck down the suit, ruling that such secret tests are not an invasion of privacy. A 1997 American Management Association study found that one in 20 companies screens its employees for genetic conditions—"an extraordinarily high number," says Mark Rothstein, a law professor and expert on genetic discrimination.

Insurance discrimination has become legendary. In one case, an insurer offered to pay for a prenatal test for cystic fibrosis, but there was a catch: If the test came back positive, the family would have to abort the child or lose their coverage. In a case publicized by

Newsweek, a two-year-old boy was diagnosed with fragile X syndrome, which causes mental retardation, and the insurer dumped the entire family of six, even though no other member had the disease. A 1996 Georgetown University study found that 22 per cent of people with inherited illnesses, or members of their families, reported being denied health insurance.

Genetic tests are spreading through society. In a South Carolina child custody case, a judge ordered the mother tested for Huntington's disease. Lori Andrews, a law professor who has written extensively about genetic issues, wonders if this will become routine. "A court could test him for the prostate-cancer gene and her for the breast-cancer gene," she says dryly, "and give the child to whomever has the longest estimated life span." In another legal twist, some scholars have argued that giving birth to a disabled child amounts to child abuse—and at least one court has entertained the possibility of such children suing their parents for bringing them into the world.

Many corporations require job applicants to submit to psychological testing. As genes are found that correlate with psychological traits, why not add a genetic profile? Schools might conduct genetic testing for IQ—but the results could be a self-fulfilling prophecy. Studies have documented how labeling students affects their performance, as well as teachers' evaluations of their work.

Of course, genetic testing can't make absolute predictions for most conditions. Genes usually reveal a predisposition, says renowned geneticist Sydney Brenner, and "the people most interested in probabilities are insurance companies, governments, and all the other institutions that are not interested in individuals as such."

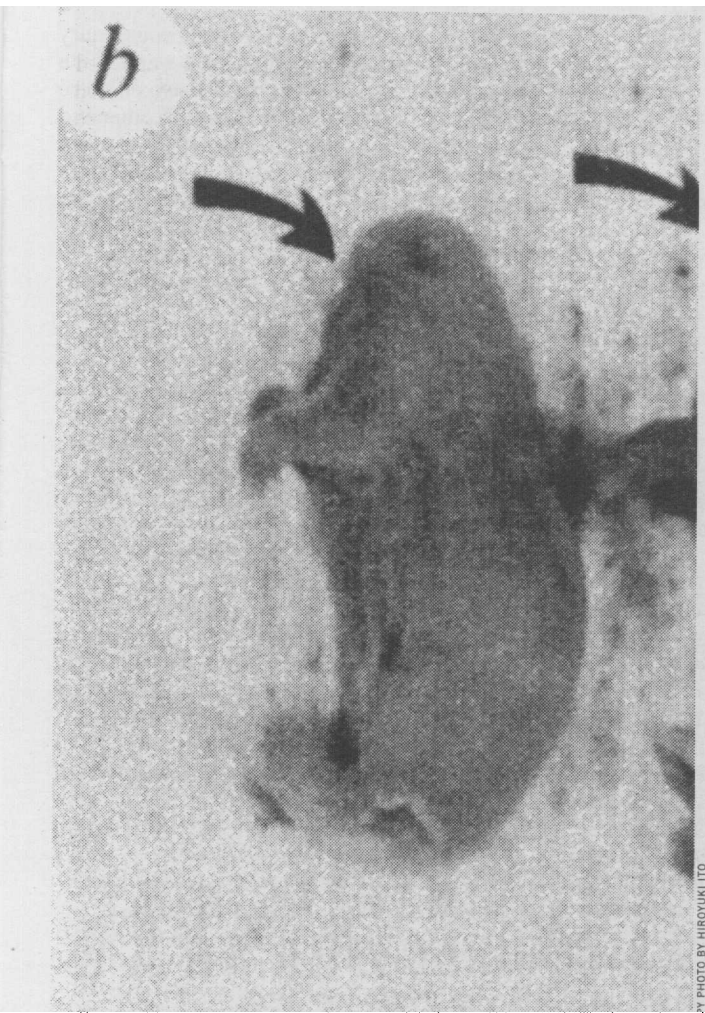
But corporations may soon peddle genetic probabilities to parents. Prenatal testing is currently confined to severe abnormalities, such as cystic fibrosis. But as more genes are discovered, more tests will become available—in no small part because they can generate revenue. "Each pregnancy will be thought of as tentative until the fetus has passed dozens or hundreds of genetic tests," writes Lutheran theologian Ted Peters. "The perfect-child syndrome may lead couples to try repeated pregnancies, terminating the undesirables."

Of course, some parents are reluctant to undergo the ordeal of abortion, but in vitro fertilization, with its test-tube embryos, makes this procedure clinical and painless.

IVF accounts for only a fraction of American births, but it has just become possible for women to freeze their eggs. This is a major breakthrough, because eggs taken from a younger woman and frozen are less likely to cause birth defects than eggs produced later in life. Women now have an incentive—which will no doubt be intensified through marketing by IVF clinics—to harvest their eggs for later test-tube fertilization.

Choosing among numerous eight-cell embryos will make it chillingly easy to enact society's prejudices, says the philosopher Philip Kitcher. "Parents will say, 'I want a kid who's going to succeed and if a doctor says that my kid has a significant chance of being gay, well, I'm not prejudiced, mind you, but people out here in Indiana are.' And that mentality will grow. There's a ratcheting effect here—if everybody is doing it, you have to do it too."

Francis Collins, national director of the human genome project, insists such genetic selection would be "a very sloppy way to try to produce your perfect offspring." Tests would be unreliable, because most mental and emotional traits are composites of "many genes, each one of which is quite weak, with profound effects from the environment." But, Collins acknowledges, "We're increasingly moving to a new-car mentality toward our kids—pick one off the lot and if it's not what we want, take it back."



than others—veers in that direction. As Dorothy Nelkin and M. Susan Lindee write in their book *The DNA Mystique*, "DNA has taken on the social and cultural functions of the soul. It is the essential entity—the location of the true self—in the narratives of biological determinism."

If the United States devolves into a biocracy, our version won't be totalitarian but driven by the market and individual choice—parents wanting to do the best for their children, and a society that dismantles social welfare programs on the false but seductive premise that human attributes are "all in the genes."

"Suppose," says CUNY sociologist Barbara Katz Rothman, "you're a working mother in a fourth-floor walk-up, and you get a prenatal test saying your kid will need a wheelchair. No one will force you to have an abortion, but they'll inform you that there are no services for people in wheelchairs, and that the government has cut back disability care of all kinds. Then they'll say, *you* choose. In that case, choice itself becomes a method of social engineering."

As reported in *Nature*, scientists have created a headless mouse.

Consider sex selection. Techniques are being developed to distinguish sperm that produce males from those that produce females. Now parents can choose the gender of their children even before egg and sperm meet to form an embryo. "Would we say, 'No, you can't do this'?" asks Collins. "And if we can't object to selecting something like gender—a trait that is very clearly not a disease—then how can we object when the trait has an association with disability?"

Collins thinks society would recoil at this "market-driven, services-to-the-wealthy prenatal scenario." But we haven't yet. In vitro fertilization clinics are completely unregulated by federal law, even though they offer a staggering array of options. The newest service, according to *The New York Times*, is "embryo adoption," in which infertile couples buy embryos created with other people's sperm and eggs. The embryo is implanted in the "adoptive" mother, who carries it to term. One couple chose an embryo based on how likely it was to have blond hair and fair skin.

IN DISCUSSIONS OF genetics, many people raise the specter of Nazi eugenics. But the analogy can seem overblown, because the Nazis were so extreme. Still, there's a lesson in the scientific worldview that gave rise to the Final Solution.

"One can speak of the Nazi state as a 'biocracy,'" writes Robert Jay Lifton in his book *The Nazi Doctors*. "The model here is a theocracy," but the high priests were geneticists and biologists who posited that Aryans were biologically superior to other races. The greatest German biologist of the era, Ernst Haeckel, wrote that because the "lower races" are "nearer to the mammals (apes and dogs) than to civilized Europeans, we must, therefore, assign a totally different value to their lives." By this logic, it is easy to understand how one German doctor could describe Nazism as "nothing but applied biology."

The United States, of course, is not a biocracy. But the belief that DNA is destiny—determining everything from intelligence, to fitness for parenting, to which lives are more valuable

THE COUPLE WHO wanted a blond, fair-skinned child made their selection based on the ethnicity of the embryo's biological parents. But it won't be long until the genes for hair and skin color are found. Could this couple then perform petri-dish plastic surgery, changing the genes to make their baby look more Nordic? Many parents might want to make cosmetic changes: A 1992 March of Dimes/Louis Harris survey found that more than 40 per cent would use genetic engineering to "improve" the physical or intellectual traits of their children.

Right now, gene manipulation isn't easy, let alone safe. Researchers can add genes, but they don't know how to guide them to specific sites on the long DNA molecule. If the new gene lands in the wrong spot, it could interfere with another gene and cause birth defects. With animals, researchers discard the deformed newborns and keep the rest, but that obviously wouldn't be countenanced for humans, at least not in democracies. What Josef Mengele would have done with genetic engineering is another matter altogether.

Enter cloning. Its real value lies not in churning out genetic copies, but in enabling scientists to perform targeted gene transfers. Let's say researchers want to replace a mutated gene with the normal version. If scientists simply put the gene into the cell, it will sometimes replace its counterpart. The problem is that this happens only about once in every million tries. Until recently, there was no way scientists could make those one-in-a-million cells grow into a whole animal. But cloning provides this crucial missing step, for it is essentially a technique to make any cell act like a fertilized embryo and grow into an adult.

So with humans, says Silver, an embryo could be grown to several million cells in a lab. Those cells could then be flooded with the desired gene, and the few that successfully took it up could be fished out. One of those could then be cloned, and the result would be a human with the new gene in exactly the right place.

The world recoiled at cloning, and it might well balk at growing a human partway just to

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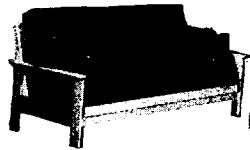
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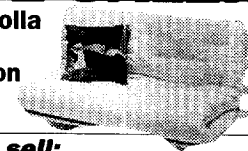
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SCHOOLS

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 get enough cells to tinker with. But such revolution may already be slackening. "I just chaired a meeting," Andrews says, "where a doctor got up and announced, 'I'm now taking applications for human cloning.'"

A few scientists have argued that to increase the supply of donor organs, it would be perfectly permissible to grow brainless but otherwise whole humans. As reported in the journal *Nature*—which published an unnerving photo of the creature—this feat has actually been accomplished by scientists who produced headless mice.

While this prospect horrifies most people, its defenders argue that without a brain a human cannot feel pain, and the harvested organs could save lives.

"YOU CAN SEE where all this technology is going," says Wexler, the Huntington's researcher. "Scissors-and-paste genetic techniques will probably be doable in the future." Then we will be tempted—not, at first, to transform human nature, but to make small medical alterations.

What about more complex changes? The brain contains 1 trillion cells, and a thousand times that many intracellular connections. Any gene that altered the brain beyond what occurs in normal human variation would not only have to coordinate with all these cells, but blend into the intricate developmental dance that forms this most amazing organ. It would be so easy to do harm.

It is widely believed that the human brain has an innate "language instinct." If we attempt to alter the mental template, we might inadvertently short-circuit that faculty. And what exactly is intelligence? A large body of work shows that it is not an abstract computational faculty, but one highly influenced by—even dependent on—emotions. Manic depression, for example, has been correlated with artistic creativity. If we alter the genes that contribute to mental illness, we might make ourselves duller.

Of course, eugenic "enhancement" is still in the realm of science fiction. But for how long? "In 100 years, we'll know 15 or 20 genes that help humans have better intelligence," says Leroy Hood, a pioneer of the Human Genome Project, "and we could give those to our kids." Hood, who holds a professorship endowed by Microsoft's Bill Gates, with whom he also collaborates on a biotech business venture, has "no hesitation about doing things that improve the human gene pool and heredity."

What other traits might be engineered? "Suppose we sent people to different planets," says Hood. "I can imagine refashioning humans to live in very different environments—hotter or colder climates, less or more oxygen." Silver sees the possibility of enhancing the senses—being able to see infrared light, or hear and smell as well as a dog. And he sees humans living hundreds of years, or even longer.

The physicist and futurist Freeman Dyson looks forward to an era "when kids are able to buy a genetics kit and build their own dinosaurs. Just think if you had little dinosaurs that were really alive!" He pauses. "Of course, that could be subject to tremendous abuse."

John Campbell, a neuroscientist at UCLA, isn't interested in Jurassic pets. He insists we have a moral imperative to hasten our evolution. Indeed, he sees human beings as "biological intermediates" whose primary purpose is to "give rise to the final thing in biology," a perfect life form. "Anyone who cherishes human qualities must embrace their continued development at the greatest possible rate," Campbell writes. "Can you imagine any greater personal tragedy than evolution aborting you as a Neanderthal or monkey or germ—or mere human being?"

This is the stuff of cults. And, in fact, Campbell foresees "bands of intellectual zealots fanatically devoted to their religion of generative

evolution and to their private autoevolutionary church." Darwinian competition—and quite possibly warfare—would occur between these groups as they tried to dominate each other and to engineer traits, conceivably even aggression, that might give them an advantage. Campbell's vision subjugates every moral value to winning the Darwinian struggle: "Few people have enough education or technical opportunity to take a shot at the frontier of autoevolution. This unfairness does not matter. . . . Evolution depends upon the fortunes of the singularly successful and not the majority."

Silver hopes genetic engineering will be as available as the polio vaccine—which sounds fine until one remembers Africa and Asia, where the vaccine often isn't available and polio outbreaks still paralyze and kill. Injustice could become genetic: The great mass left behind, says Campbell, "won't be an underclass, it'll be an underspecies."

"BULLSHIT," SNAPS RICHARD Lewontin, a Harvard zoologist and veteran critic of genetic hype. He disparages the notion that humans could genetically engineer ourselves into separate species. Even if such genetic manipulation were possible, small amounts of interbreeding

'WE'RE INCREASINGLY MOVING TO A NEW-CAR MENTALITY TOWARD OUR KIDS—PICK ONE OFF THE LOT AND IF IT'S NOT WHAT WE WANT, TAKE IT BACK.'

would spread the eugenic genes into the general population. "For species formation," he says, "you have to be truly isolated," something that would be impossible over generations.

And who's to say what evolutionary progress really is? The ultimate life form, the one best suited to survive into eternity, might be a cockroach or a virus.

Ultimately, though, people will have to face the existential question: Should we put ourselves in charge of our own evolution?

Absolutely not, says eco-activist Jeremy Rifkin. "Genetic slavery" is what he calls engineering the human gene pool. "It's forcing someone else not yet here into limits we've imposed on them, based on our cultural biases." Seven generations ago blacks were still in shackles, and 20 generations ago the Catholic Church censored Galileo: Would we want people with those mores to have chosen our genes?

Orchestrating evolution is a prospect as spellbinding and intoxicating as vertigo. It is the closest science will ever come to the power of creation. Clearly, some scientists are drunk on this power—and on the vision of a genetic utopia, free from disease, stupidity, and all human limitations. But if the 20th Century has one overriding message it is: Beware utopias. **V**

Research assistance: Mina Seetharaman and Catherine Donaldson-Evans